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Level 22
530 Collins Street
Melbourne VIC 3000

Postal Address:
GPO Box 2008
Melbourne VIC 3001

T 1300 858724
F 03 9609 8080

Istvan Szabo
Adviser
Australian Energy Market Commission
Level 6, 201 Elizabeth Street
Sydney NSW 2000

Dear Mr Szabo

Rule Change Request: Generating System Model Guidelines

The Australian Energy Market Operator (AEMO) welcomes the opportunity to provide further information and clarification on its rule change request submitted on 1 November 2016 and to provide feedback on the consultation paper published by the Australian Energy Market Commission (AEMC) on 15 March 2017.

As outlined in AEMO's rule change request, AEMO relies on power system modelling and simulation for secure operation of the National Electricity Market (NEM) power system. Since submission of the rule change request, the need for additional modelling information has been further reinforced by lessons learned from AEMO's investigations of the South Australia (SA) black system event on 28 September 2016, more frequent occurrence of extreme events, introduction of various jurisdictional energy transformation and renewable energy targets, and imminent deployment of new and emerging power system technologies at the transmission and distribution system level.

AEMO recommends that these challenges be managed with the support of efficient and effective regulatory mechanisms to ensure the most cost-effective measures are used in the long-term interest of consumers, and consistent with the National Electricity Objective (NEO). To achieve this, there is a need for adequate, up-to-date, clear, and transparent rules with respect to power system modelling and data requirements.

AEMO has reviewed the consultation paper, and offers a number of comments – these are detailed in the attached submission.

If you would like to discuss this submission further, please do not hesitate to contact me.

Yours sincerely

Mark Stedwell

GM System Capability

Attachments: AEMO submission – Generating System Model Guidelines' rule change

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1. Introduction

AEMO has reviewed the AEMC's consultation paper on the AEMO's rule change request for revision of generating system model guidelines. AEMO's comments on the AEMC's consultation paper relate to the following areas:

- Changing power system conditions
- Data provision requirements on existing generators or generators half-way through the connection process
- Cost of obligations
- Format, sensitivity and restrictions of requested information
- Additional matters for consideration

2. Changing power system conditions

The consultation paper states that: "A key question for consideration therefore is whether these changing power system conditions mean that current model data provision obligations are no longer sufficient to allow for effective assessment of the power system by AEMO''. Furthermore, it raises the question: ''Are changing power system conditions impacting on the ability of AEMO, and other parties, to accurately model the power system?''

AEMO notes that access to correct technical information on grid-connected equipment is critical for managing power system security such that system response under all conditions, including extreme events, can be anticipated and managed effectively.

In addition to several examples provided in AEMO's rule change proposal, lessons learned from AEMO's investigations of the SA black system event on 28 September 2016 (SA Report), and assessment of new generator connection applications in various NEM regions has further highlighted the need for more detailed modelling information for generating systems, as well as the need for provision of modelling information by owners of other, non-generation plant. The following key examples are discussed below.

- Root mean-square (RMS)-type simulation models are inappropriate for analysing whether a viable island can be formed in SA following loss of Heywood Interconnector. This has been demonstrated in the SA Report[1].
- The SA Report indicates that "as the number of faults on the transmission network grew, nine wind farms in the mid-north of SA exhibited a sustained reduction in power as a protection feature activated. For eight of these wind farms, the protection settings of their wind turbines allowed them to withstand a pre-set number of voltage dips within a two-minute period. Activation of this protection feature resulted in a significant sustained power reduction for these wind farms''.

  This protection feature is not represented in the simulation models submitted to AEMO for any of the affected wind farms. AEMO is also unaware of this feature in any other wind turbine simulation models it has received. Accordingly, simulations of wind farm performance using the wind farm models currently available to AEMO would not display disconnection or offloading in response to a large number of faults

[1] AEMO, 2017, *Black System South Australia 28 September 2016 – Final Report*. Available at: https://www.aemo.com.au/-/media/Files/Electricity/NEM/Market_Notices_and_Events/Power_System_Incident_Reports/2017/Integrated-Final-Report-SA-Black-System-28-September-2016.pdf

in quick succession. Furthermore, the SA Report concludes that "had the generation deficit not occurred, AEMO's modelling indicates SA would have remained connected to Victoria and the Black System would have been avoided. AEMO cannot rule out the possibility that later events could have caused a black system, but is not aware of any system damage that would have done this''.

This example highlights the need for more detailed and accurate models of generating systems, and associated control and protection systems.

- Experience gained from assessment of a number of non-synchronous generating systems during a connection application process, and the SA blackout investigations reveals that, in many cases, the RMS-type models predict significantly faster active power recovery following fault clearance compared to the measured responses or the more detailed electromagnetic transient (EMT)-type simulation models. The impact would be substantial in the context of the SA power system as any transient power reduction in the wind farms due to contingency events would be reflected onto the Heywood Interconnector. Lack of sufficiently accurate models results in optimistic and potentially insecure transient stability limits calculations for the Heywood Interconnector.
- Lack of detailed modelling information can result in the conservative operation of the power system. As an example, simulation models of conventional synchronous generators provided to AEMO do not account for any protection or susceptibility mechanisms with respect to rapid variations in the rate of change of frequency (RoCoF). To manage the uncertainty in the event of a credible risk of separation in the SA, AEMO has recently implemented a 50 MW limit on the Heywood Interconnector, based on consideration that some of the generating units may not withstand a RoCoF value of as low as 0.5 Hz. More detailed and accurate models would allow for an increased interconnector limit by providing a better understanding of the generating systems' limitations and mitigating the risk of generator disconnection due to high RoCoF.
- Significant increase in connection of wind and solar farms in remote parts of the NEM is observed where, in some circumstances, the particular wind turbine and solar inverter types are connected to parts of the network with lower system strength than the minimum permissible limits for which the generating units are designed and connected elsewhere in the world. The standard design of generating units would not, therefore, be appropriate.

  Common practice applied until recently for new generator connection assessment is such that either RMS-type models are used exclusively or, in the case of using EMT-type models, they would be used to provide confidence in the accuracy and adequacy of the RMS-type models rather than replacing them. However, in a few recent connection applications the Generators and their original equipment manufacturers (OEMs) have recommended the use of more detailed and accurate EMT-type models only for negotiation of generator performance standards. They have also advised that the necessary RMS-type model would be developed and submitted after the AEMO and network service provider (NSP) have accepted the EMT-type model and the generator performance standards negotiated based on this detailed model.
- Adverse interaction between the generating system and surrounding power system. Experience exists where the adverse control interactions between a non-synchronous generating system and adjacent power system was not identified during the design

stage and negotiation of generator performance standards. This primarily stemmed from the use of RMS-type models and simulation tools and their inherent limitations in representing control systems that can adversely interact with each other.

Considering the materiality of the issues discussed above, AEMO urges the AEMC to give consideration to these matters.

3. Data provision requirements on existing generators or generators half-way through the connection process

The consultation paper puts forward a number of questions on the extent to which the proposed rule change should apply to existing generators or generators half-way through the connection process, in particular:

- Question 4: Does AEMO have scope to gather sufficient information under existing NEL/NER provisions?
- Question 8: What data provision requirements should apply to a generator that is half-way through the connection process, when new data provision requirements are introduced?
- Question 11: Should AEMO be able to request additional modelling data from existing generators who are already registered and have executed connection agreements?

Question 4 is predicated on the use of market information instruments under section 53 of the National Electricity Law (NEL). AEMO submits that this is not applicable in the case of the type of information AEMO seeks in this instance, as section 53 of the NEL only applies to a 'relevant function' of AEMO, which does not include the function it performs as power system operator and wholesale market operator under section 49 of the NEL.

AEMO considers that provision of relevant and accurate data and models is imperative for all generators. The criteria and conditions for requesting an existing generator to provide additional modelling information should be primarily decided based on the impact on power system security or other Registered Participants (as set out in the rule change proposal), and irrespective of application or connected status.

The connection process is an iterative process and AEMO always expects that an applicant will submit a range of models through as design progresses. Modelling changes can arise for a number of reasons, including changes in generating units' type or balance of plant selection, parameter refinements, updates to models by the OEM or identification of performance/compliance issues that needs to be resolved.

Appropriate and accurate data and modelling information is an enduring obligation and a necessity. The purpose of the provision of data and models is multi-faceted – the initial use for assessment of the suitability of proposed plant and its performance standards is just one aspect. The determination of plant's capability to achieve its agreed performance standards and then later, the ongoing management and assessment of power system security confirm that model provision and use is not just a simple hurdle that stands between application and connection. Once a plant is in service, its models are used in long-term power system planning, assessment of new connections, development of constraint equations, procurement of ancillary services, short-term operational planning and incident investigations, and in real-time operations through stability assessment tools.

To manage power system security, it is imperative that appropriate simulation models and data are available to AEMO. As the power system characteristics and its connected elements evolve, there is a requirement for modelling tools and data adequate for investigation and

assessment of various matters of power system security with a focus on areas of specific concern at that time, in a particular scenario. The modelling capability needs to evolve alongside the power system. The use of models in power system simulations and assessments is fundamental to understanding the technical performance capability and limits of the interconnected power system. Without the ability to perform fit for purpose simulations, AEMO would be forced to operate the power system relatively more conservatively (as an example see Section 2 on the lack of detailed information on the RoCoF withstand capability of synchronous generators).

AEMO considers that the NER already acknowledges the need for models to be periodically reviewed and updated. Clause 5.7 deals with testing and for compliance purposes and acknowledges that adequate analytical models are a necessity for AEMO in undertaking its obligations in relation to power system security. In particular, clause 5.7.6 provides a process for testing where models are considered inadequate.

AEMO's experience in requesting detailed modelling information or additional data from existing generators is varied. To establish consistency AEMO recommends the AEMC to consider setting out clear and transparent rules with respect to power system modelling and data requirements as the current Rules would allow inconsistency in the extent of modelling information provided by different Generators. It is AEMO's view that the power system must be able to be analysed as a whole, and piecemeal assessment is not an option.

4. Cost of obligations

While AEMO is appreciative of the additional cost for the provision of more detailed or additional modelling information, it recommends that any arguments as to the cost of compliance should be weighed against the cost of major events, such as blackouts, other supply disruptions, and involuntary load shedding which may occur due to inability of deficient or inaccurate simulation models to correctly predict and mitigate power system security concerns. AEMO considers that any costs associated with additional modelling requirements, being in the order of several tens of thousand dollars, would be significantly outweighed by the prevention of the events discussed in Section 2, some of which may cost several tens of million dollars if they are not correctly understood and mitigated through detailed power system modelling and simulation.

Furthermore, examples exist where simulation models of the generating systems are materially different from the actual plant response. To manage the impact of such generating systems on power system security, it may be necessary for the NSP or AEMO to apply constraints on the operation of such plant. Provision of more accurate and appropriate simulation models reduces the risk of generating systems being constrained-off due to major inaccuracies in the model, or as a result of later developments in the adjacent network and manifestation of interaction phenomena that could not be predicted by simpler RMS-type models.

The consultation paper also raises a question as to whether the cost of these obligations may form a barrier to entry for new Generators. AEMO notes that in dealing with a number of major wind turbine and solar inverter manufacturers for a number of new connection applications, it has, so far, been able to receive detailed EMT-type models from three major solar inverter, and four major wind turbine manufacturers. AEMO also understands that a number of OEMs are currently working towards developing more detailed models. AEMO does not, therefore, agree that additional model requirements could be an impediment on new entrant Generators.

5. Format, sensitivity and restrictions of requested information

5.1. Format

The consultation paper mentions that "AEMO's rule change request does not specify whether EMT-type models provided to it should be in a source code or encrypted format''. However, the proposed clause S5.2.4 (b) (6) indicates that:

> *to AEMO, model source code associated with the load flow and dynamic simulation model in subparagraph (5) in an unencrypted form suitable for at least one of the software simulation products nominated by AEMO and in a form that would allow conversion for use with other software simulation products by AEMO;*

AEMO considers that the rule change as proposed would deliver the necessary value with a black-box EMT-type model. AEMO introduces other mechanisms to gain confidence in veracity of these models (see Section 6 of this attachment) rather than the need for provision of model source codes. The requirement on provision of RMS-type model source codes will remain and is necessary to enable AEMO to independently manage any software version changes. AEMO notes changes in the simulation platform version for the EMT-type software generally occur much less frequently than for the RMS-type software. Additionally, models developed in older versions of the EMT-type tools can often be used in newer versions without any issues. In any case, AEMO considers it is the responsibility of connecting Generator to have contractual agreements in place with the relevant OEM(s) to update any black-box EMT-type models if the obsolete model version cannot be used in a newer version of the EMT-type tool used by AEMO.

5.2. Sensitivity

The consultation paper discusses briefly the potential sensitivity: "In assessing this issue, it will be necessary to consider whether EMT-type models are likely to be significantly more commercially sensitive than an RMS-type model and whether current encryption requirements can provide adequate protection. The Commission understands that the relative simplicity of RMS-type models means that to date, the encryption process has provided adequate protection for these kinds of generator model data. However, the more detailed nature of EMT-type models could mean that encryption does not provide sufficient protection''.

AEMO notes that the sensitivity and intellectual property (IP) issues associated with the EMT-type models primarily relate to the control and protection systems of the generating units, and other dynamic plant that can differ between manufacturers. Details of these features are not observable by the users of the black-box models. Furthermore, the rule change proposal does not put forward any requirements on provision of associated transfer function block diagram representation. AEMO does not, therefore, agree that the more detailed nature of EMT-type models could mean that encryption does not provide sufficient protection.

5.3. Restrictions

When it comes to potential restrictions in distribution of the detailed EMT-type models, the consultation paper notes that: "Furthermore, even if generators already possess the EMT-type models from manufacturers, the release of those models to any third party, including AEMO, may be restricted under private confidentiality agreements. Therefore, the ability to comply is likely to be dependent on the particular circumstances of each party''. AEMO considers the described situation unlikely to occur for the following reasons:

- OEMs have provided these models to AEMO and relevant NSPs rather than the relevant Generator.
- To date, AEMO and relevant NSPs have received such models under non-disclosure agreement with the relevant OEM(s) where the relevant Generator is not part of such confidentiality agreements.
- With the proposed rule change the requirement for AEMO to adhere with the confidentiality of information would be covered under the national electricity law (NEL) and National Electricity Rules (NER)[2].
- A similar approach is often adopted when the OEM submits the model source code for RMS-type models to AEMO only, and in most case cases not to the relevant Generator. AEMO considers that this approach has worked successfully for several years.

6. Other matters for consideration

Recent experience gained from assessment of a number of non-synchronous generating systems as part of a connection application process, and the SA blackout investigations has highlighted the need for higher confidence in the veracity of simulation models submitted before connection assessment studies commence. These issues were not proven to be critical at the time of submitting the rule change proposal, and were not therefore included in the original rule change request submitted on 1 November 2016. These proposed additional requirements are highlighted below.

- Pre-validation of models against the actual response of generating units, dynamic reactive support plant, and battery storage units (if applicable) with identical control systems and settings. The pre-validation of models prior to commissioning tests of the whole generating system onsite will significantly reduce the risks of non-compliance in the commissioning process set out in the NER[3]. Another advantage of model pre-validation for EMT-type models is that it provides sufficient confidence in the adequacy and integrity of the submitted models without the need for AEMO to access the model source codes. Pre-validation of simulation models can be demonstrated using a type-test approach.
- Depending on system strength, pre-validation may need to be done on either RMS- or EMT-type models.
- Where EMT-type models are required, the accuracy and adequacy of EMT-type models submitted to AEMO for all individual elements of the generating system should be pre-validated against the actual response of these elements with identical

[2] Because AEMO holds a significant amount of confidential information in order to fulfil its statutory functions, the regulatory framework for the National Electricity Market (NEM) includes extensive obligations on AEMO to ensure that confidential information is protected, and only used or disclosed to the extent necessary for AEMO to perform its functions. These legal obligations were introduced to address such a situation, avoiding the need for AEMO and to negotiate NDAs with all disclosing parties. This way, all confidential information held by AEMO is subject to consistent obligations of confidentiality that have the force of law. AEMO's confidentiality obligations are set out in the National Electricity Law (NEL), a legally statute in each jurisdiction of the NEM. The National Electricity Rules (NER) are a statutory instrument that all Registered Participants must comply with, including the legal confidentiality obligations under clause 8.6 of the NER. These laws can be found in full at the following links:
NEL - please see sections 54 to 54H:
http://www.legislation.sa.gov.au/LZ/C/A/NATIONAL%20ELECTRICITY%20(SOUTH%20AUSTRALIA)%20ACT%201996/CURRENT/1996.44.UN.PDF
NER - see Chapter 5, (Schedule 5.2 clause S5.2.4(b)(6) and (c)(2)), also Chapter 3 (clause 3.13.3(k) and (l)(2)) and Chapter 8 (clause 8.6): http://www.aemc.gov.au/Electricity/National-Electricity-Rules/Current-Rules.html

[3] Refer to NER clause 5.7.3 (a)

control systems and settings for the minimum SCR and X/R ratio for a specific connection point.

- For clarity, references above to ‘individual elements’ include, but are not limited to, generating units, dynamic reactive power support plants, and battery storage units (if applicable).
- Changes in the control systems and/or settings of the individual elements are necessary if the submitted EMT-type model exhibits uncharacteristic or unexpected responses. Depending on the extent of the issue, the required changes may need to be done on either or both of the actual plant or corresponding EMT-type model.